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Eric S. McGee
Eastern Illinois University

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Ecology and Interspecific Relationships of the Painted Turtle, (Chrysemys picta) in a Marsh-fen Ecosystem.

(TITLE)

BY

Eric S. McGee

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
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ABSTRACT

An ecological study of the painted turtle (<u>Chrysemys picta</u>) was conducted at the Fox River site in Chain O' Lakes State Park in northeastern Illinois from March to September in 1987. Findings were compared to two studies in 1986 concerning the common snapping turtle (<u>Chelydra serpentina</u>) and Blandings turtle (<u>Emydoidea blandingi</u>) also present in the area. Population densities and composition were evaluated to determine the degree of interspecific competition.

Two hundred-forty five turtles were captured in 1986 and 1987. Painted turtles comprised 75 percent of the chelonian population, while Blandings turtles and snapping turtles made up 15 and 10 percent respectively. Densities of the three sympatric species were 114.1, 11.7 and 8.6 individuals per hectare. Biomass estimates show <u>Chelydra</u> predominating with 23.7 kg/ha followed by <u>Chrysemys</u> (15 kg/ha) and <u>Emydoidea</u> (11 kg/ha).

Intrasite differences show <u>Chrysemys</u> densities in the five ponds varying between 21.4 and 139.5/ha with highest densities in the most vegetated ponds. Conversely, <u>Chelydra</u> was relatively most abundant in relatively unproductive ponds (19.0/ha). <u>Emydoidea</u> utilized these ponds more in the spring and the richly vegetated ponds in the summer and fall. Biomass estimates for painted turtles ranged from 4.4kg/ha to 29.7kg/ha. Snapping turtles biomasses ranged from

14.7kg/ha to 58.9kg/ha, and Blandings turtles biomasses ranged from 10.5 to 25.5 kg/ha. Chrysemys was most dense in highly vegetated ponds and where Chelydra were least dense. Potential for food competition include a moderately high overlap in diet between the two species. Competition between the three species may be alleviated by differences in diet, feeding behavior, activity periods and spatial activity.

Chrysemys has the most generalized diet of the three species, while Emydoidea was most specialized. Painteds were closest to snappers in food utilization. Densities of the three species were inversely correlated, while movements and home ranges were positively correlated with the degree of specialization in diet. Chrysemys utilized surface mats of vegetation for the preponderance of their activity while Emydoidea foraged in the shallows; Chelydra was highly variable in their activity areas.

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INTRODUCTION

Little is known about the densities or interactions of multispecies communities of turtles (Bury, 1979). Among the few published works dealing with this subject are Berry's (1975) study of two sympatric species of *Sternotherus*, Vogt's (1981) study of congeneric map turtles, and Congdon et al. (1986) who compared densities and biomass of *Chrysemys*, *Chelydra* and *Emydoidea* in Michigan.

Chain O' Lakes State Park is a marsh-fen ecosystem in Lake County, Illinois, inhabited by three species of turtles In 1986, the ecology of two of these, *Chelydra serpentina* and *Emydoidea blandingi* were investigated (Budhabhatti, 1987 and Rowe, 1987). This is an ecological study of the remaining species the painted turtle, *Chrysemys picta*.

The main objective of this study is how population density and composition varied relative to habitat and cohabiting chelonians. Diet, foraging behavior, temporal and spatial activity of *Chyrsemys* were analyzed and compared with *Chelydra* and *Emydoidea* to gain insight into how these species coexist in the area.

MATERIALS AND METHODS

Turtles were captured using baited hoop nets, dipnets, basking traps, trammel nets and hand collecting. Hoop traps, baited with chicken liver and fish, were checked four times a day (0700, 1100, 1500, 1900).

Basking traps consisting of a wire mesh basket were suspended on one side of a log near shore. Basking turtles could be frightened into the trap if one approached them rapidly from the opposite side.

Following capture, turtles were measured, weighed and permanently marked. Standard measurements were taken with forestry calipers included: carapace length, carapace width, plastron length and shell height (After Carr, 1952).

Measurements of the abdominal and pectoral laminae of the plastron were taken with vernier calipers. Weights were taken to the nearest 10 grams with a Pesola hanging scale. Age was determined when possible by counting growth annuli on the plastron (Sexton, 1959). Sex of Chrysemys was determined by secondary sexual characteristics. Individuals possessing elongated foreclaws and elongated tails were recorded as males. Combinations of marginal scutes were notched with a hacksaw blade in accordance with the numbering system devised by Cagle (1939). During May and June, numbers were painted on the shells using white acrylic paint, allowing identification without recapture. This method was abandoned later due to carapacial scute shedding.

Eleven Chrysemys, 2 Chelydra and 1 Emydoidea were equipped with single-stage radio transmitters throughout the study. The transmitters, waterproofed with beeswax and dental acrylic, glued to the posterior margin of the carapace. All turtles were released at the site of capture, and radio-tagged individuals were radiolocated at least once a day. Locations were plotted on maps prepared from aerial photographs. Time, date, weather conditions, water temperature at 15 cm, and vegetation associations were recorded for each location.

Dietary samples were obtained by stomach flushing using a continous action syringe equipped with plastic tubing (Legler, 1977). The samples were collected and preserved in ten percent formalin. Fecal samples were obtained by placing the turtle in a tub of water for 1 to 4 days until defecation occurred. Five turtles, accidently killed, were preserved and subsequently dissected in the fall of 1987 to obtain stomach and intestinal contents. Samples were separated and analyzed qualitatively and quantitatively. Animal and plant material were identified to the lowest possible taxa. Frequency of occurrence and volumetric analyses were tabulated for each sample. Frequency of occurrence is defined as the percentage of samples in which a specific food item occurred in the stomach contents. Volumetric analysis was used to measure the quantity of each type of food (Windell, 1970).

Observations on basking behavior and foraging activity were made daily from a boat, or shore using binoculars. Numbers of active turtles, weather conditions, air temperature and time were recorded.

Gravid females were determined by palpating inside the femoral pockets. Oxytocin (Ewert and Legler, 1978), was injected into eight gravid Chrysemys and 2 Emydoidea to induce oviposition. The eggs were weighed, measured, marked and placed on damp cotton batting in plastic bags.

Vegetation types and locations were determined (Winterringer and Lopinot, 1977) and mapped for each pond. Plant densities were determined in pond D, using the line intercept method. A 50 m length of nylon twine marked in meter increments was suspended above the waters surface and all plants below it were counted.

Densities of individual populations were calculated through the Schnabel method (Brower and Zar, 1977). Biomass estimates calculated by determining pond populations. The total captured biomass was multiplied by the percentage of turtles caught in order to determine the remaining biomass. Dietary overlap and specialization were determined using Morisita's index (Horn, 1966) and H' diversity index (Schoener, 1968). Data were analyzed by Chi-square and ANOVA (Schefler, 1980).

STUDY AREA

Chain O' Lakes State Park in northeastern Illinois is a natural area of deciduous forest, marsh, prairie, sedge meadow, fen and bog. The study area encompasses approximately 25 ha and is immediately west of the Fox River which flows through the park. Five ponds (A-E) were the primary focus of study. These ponds have a combined total surface area of 5.42 ha. These ponds are man-made bodies of water approximately 20 to 25 years old. They were once used as rearing impoundments for fish research in the area.

Pond A (Figure 1) is most westerly and the second smallest pond in the study area. It had a surface area of 0.16 ha, a maximum depth of 2.1 m in the east end and was surrounded by a stand of deciduous forest. *Chara* sp. the only aquatic vegetation present was chiefly submersed. Average temperature for June through September was 22.1 C.

Ponds B and C (Figure 1) are within 5 m of each other and the most centrally located of the group. Both are north-south oriented and share similar vegetation types between them. Pond B slightly southeast of pond A had a surface area of 0.27 ha. Average temperature is 20.5 C with a maximum of 29 C. Maximum depth, attained in the south end, was 2.3 m. The pond had a fishhook shape in the north arm and *Scirpus* sp. was found in this shallow water. *Chara* sp. was found along the shallow margins of the pond.

Pond C was the smallest and northern-most pond at the site. It had a backward L shape and a surface area of 0.15 ha. The deepest area, 2.3 m, is located in the northern arm. *Scirpus* sp. occurred in the shallow water on the southeast bank. Large *Chara* sp. mats occurred throughout most of the pond but was chiefly submersed. The average temperature was 22.2 C.

Pond D (Figure 2), with a surface area of 1.24 ha, is located approximately 75 m east of ponds B and C. It is an elongate body of water oriented in a northeasterly-southwesterly direction. Large cottonwoods, (Populus sp.), border the east side of the pond, while willows, (Salix sp.), grows out into the water on the west side. The maximum depth recorded, 2.9 m, was along the east side. Large mats of submersed macrophytes occurred throughout the pond with Ceratophyllum sp. and Chara sp. most predominant. Potamogeton sp., Lemna sp., Wolffia sp. and Utricularia sp. were also present. Pond D had an average temperature of 20.7 C.

Pond E (Figure 3) is the largest, (surface area 3.6 ha), and most easterly of the five. A peripheral channel of the pond runs parallel to the Fox River. Large mats of Nymphaea sp. grow in the water closest to the banks, while the remaining water is filled with Ceratophyllum sp. The eastern side of the pond is characteristic of marsh with Carex sp. and Typha sp. predominating. Pond E is highly eutrophic with a maximum depth of 1.5 m. The average temperature was 19.4 C. Lemna sp. and Potamogeton sp. are also present.

RESULTS

Chelonian Composition: Painted turtles were the most numerous chelonian species in the study area. Of 245 turtles captured in 1986 and 1987, 75 percent were Chrysemys, 15 percent were Emydoidea and 10 percent were Chelydra. Based on capture- release data, the total population of turtles was estimated at 729: comprising 618 (84.9%) Chrysemys, 64 (8.7%) Emydoidea and 47 (6.4%) Chelydra (Table 1). In terms of density, this translates into 114.1, 11.7 and 8.6 turtles per hectare respectively for the above species.

Although painted turtles were the most numerous, they ranked second with respect to biomass. Chelydra predominated with 23.7 kg/ha compared to 15.0 kg/ha for Chrysemys and 11.0 kg/ha for Emydoidea. In Chrysemys, females 9.0 kg/ha exceeded males 5.3 kg/ha in biomass. Emydoidea and Chelydra differed in that males had the higher biomass (Table 2, Figure 4). Immature turtles had biomasses of 4.4kg/ha (Chrysemys), 1.5kg/ha (Emydoidea) and 11.9kg/ha (Chelydra).

Both Chrysemys (X^2=1.65 P¶0.05) and Emydoidea (X^2=0.61, P¶0.05) had approximately 1:1 sex ratios. Chelydra had a skewed ratio of four males to one female which differed significantly from an even sex ratio (X^2=5.46, P§0.05). Immature turtles comprised 18.4% of the Chrysemys population. Chelydra had a greater percentage of immatures (40.0%), while Emydoidea had less (10.8%).

Intrasite Variation: Chrysemys comprised 42.9 to 91.9 percent of the chelonian populations in the five

Table 1. Population estimates, densities and biomass of chelonians in ponds A-E at the Fox River site in Chain O' Lakes State Park during 1986 & 1987. Densities and biomasses are calculated per hectare.

	C. picta	*E. blandingi*	*C. serpentina*
Pond A	10.8± 3.17	3.0± 3.40	1.0*
(95% C.I.)	(7.6-14.0)	(0.0-6.4)	(NA)
Rel. abund.	68.3	25.3	6.3 (%)
Density	67.5	18.7	6.2
Biomass (g)	24,150.0	25,523.1	18,750.0
Ponds B&C	9.0± 0.0	4.0± 4.90	8.0± 5.60
(95% C.I.)	(NA)	(0.0-8.9)	(2.4-13.6)
Rel. abund.	42.9	19.0	38.1 (%)
Density	21.4	9.5	19.0
Biomass (g)	4355.7	16,642.9	58,955.4
Pond D	100.6± 37.8	18.8± 14.4	10.0± 8.0
(95% C.I.)	(62.8-138.4)	(4.4-33.2)	(2.0-16.0)
Rel. abund.	77.8	14.5	7.7 (%)
Density	81.1	15.2	8.1
Biomass (g)	23,251.5	15,315.2	36,219.7
Pond E	502.2± 210.6	28.5± 87.6	16.0± 21.2
(95% C.I.)	(291.6-712.8)	(0.0-116.1)	(0.0-37.2)
Rel. abund.	91.9	5.2	2.9 (%)
Density	139.5	7.9	4.4
Biomass (g)	29,750.8	10,490.6	14,743.4

* Only one turtle was captured.

Table 2. Biomass estimates categorized according to sex and age of three species of turtles at the Fox River site in Chain O' Lakes State Park. Total weights in grams/hectare.

	C. picta	*E. blandingi*	*C. serpentina*
Pond A			
Males	2475.3	15,381.2	0.0 *
Females	21,643.5	10,141.9	18,750.0
Immatures	31.2	0.0*	0.0*
	24,150.0	25,523.1	18,750.0
Ponds B&C			
Males	1634.0	16,642.9	35,687.1
Females	1981.9	0.0*	16,639.5
Immatures	739.8	0.0*	6628.8
	4355.7	16,642.9	58,955.4
Pond D			
Males	8917.3	6199.8	28,427.4
Females	12,991.6	7828.7	5846.7
Immatures	1342.6	1286.7	1945.6
	23,251.5	15,315.2	36,219.7
Pond E			
Males	15,330.3	6004.4	11,431.8
Females	12,134.0	4317.2	0.0*
Immatures	2286.5	169.0	3311.6
	29,750.8	10,490.6	14,743.4
Total			
Males	28,356.9	44,228.3	75,546.3
Females	48,751.0	22,287.8	41,236.2
Immatures	4400.1	1455.7	11,886.0
	81,508.0	67,971.8	128,668.5

* none were captured.

ponds (Table 1). Chelydra and Emydoidea were always less numerous. Chelydra was relatively most abundant in ponds B and C where they comprised 38.1 percent of the chelonians. Emydoidea was relatively most abundant (20.3%) in pond A but their occurrence here was transitory and only painted turtles appeared to be residents, thus this may not be significant. Chrysemys was most dense in the productive, highly vegetated ponds D and E with 81.1 and 139.5 individuals per hectare respectively. Their lowest density (21.4/ha) was in ponds B and C. Densities of Emydoidea and Chelydra ranged from 7.9 to 18.7 and 4.4 to 19.0 turtles per hectare respectively (Table 1). Chelydra was most dense in the relatively unproductive ponds B and C with 19.0 turtles per hectare. Emydoidea were most dense in Pond A, (18.7/ha), but again this was a transitory situation in May and early June. More time was spent in pond E and the associated marsh.

Biomass estimates of Chrysemys were similar in three of the five ponds (Table 2). The lowest and highest biomass was 4.4 kg/ha in ponds B and C and 29.7 kg/ha in pond E. Emydoidea showed the least amount of variability, 10.5 kg/ha to 25.5 kg/ ha, between the ponds. Estimates for Chelydra ranged from 14.7 kg/ha in pond A to 58.9 kg/ha in ponds B&C.

Sex ratios of Chrysemys also varied between the five ponds. At the extremes, Pond A had five times as many females as males, and pond E had a two to one male to female ratio. Pond D had exactly a 1:1 ratio based on capture of 30 turtles of each sex. Sex ratios of *Chelydra* and *Emydoidea* in individual ponds could not be calculated due to small sample size.

Home Range: *Chrysemys* had the smallest average home range of the three species (0.38 ha) followed by *Chelydra* (2.20 ha see Budhabhatti, 1987) and *Emydoidea* (9.5 ha see Rowe, 1987). Movements of painted turtles were followed with radio-telemetry in pond D. They utilized the west and south portions of the pond D with greater frequency than other areas. These areas were characterized by heavy submersed vegetation and flooded *Salix*. Figures 4 and 5 show home ranges and activity centers of a male and female *Chrysemys*. Due to the limited movements of this species the activity range was essentially the same as the home range. Other than basking and nesting nearly all of the daily activity was aquatic. Outside of the nesting season, only two individuals were observed moving terrestrially. Both moved into adjacent bodies of water.

Chelydra were also primarily sedentary with only three of nine radio-tagged individuals establishing activity ranges in more than a single pond (Budhabhatti, 1987). Conversely, *Emydoidea* occupied from two to four activity ranges separated by up to a kilometer during the summer (Rowe, 1987).

Trapping data indicate that *Chrysemys* foraged throughout the day at water temperatures ranging between 14 and 35 C. No significant difference in feeding intensity was observed between early morning, mid morning, mid afternoon and early evening ($X^2 = 4.69$, P ¶ 0.05).

Trapping data for Chelydra and Emydoidea showed bimodal feeding patterns with peaks of foraging in the morning and afternoon hours. (Budhabhatti, 1987; Rowe, 1987). Emydoidea entered baited traps at temperatures as low as 14 C with peak feeding activity occurring between 18.2 and 29.0 C. Chelydra were observed feeding over a temperature range of 16 to 34 C (Budhabhatti 1987).

One Chrysemys was active as early as 0300 and remained so until 0130 the following day. Telemetry data indicated that peak activity was generally between 0600 and 2330. Observations (n= 52) show that Chrysemys basked from 0930 to 1745 with peak numbers occurring between 1100 and 1500. Over 70% of all observations were between 1100 and 1500. Chelydra were typically diurnal and activity between 2200 and 0500 was rare (Budhabhatti, 1987). Emydoidea were active between 0532 and 2225 (Rowe, 1987).

Seasonal Activity: Chrysemys were observed basking as early as the last week in March and as late as 26 September (water temp. 12 C). No further observations were conducted after this date. Turtles entered traps until 14 August; no individuals were taken in 259.0

trapping hours in September (Table 3).

Chelydra and Emydoidea at Chain O'Lakes have similar periods of activity. In 1986, Chelydra and Emydoidea were active from the last week in March to the end of October (Budhabhatti, 1987; Rowe, 1987).

Gravid female painted turtles were captured from 28 May through 6 June in 1987, and from 19 May to 3 June in 1986. One female, found dead 8 June had corpora lutea and a set of four ovulatory size follicles suggesting the possibility of a second clutch. Eight clutches were obtained by injection with oxytocin. An average of 7.6 eggs per clutch. Relative clutch mass (RCM) was 0.103. Emydoidea nested from 30 May to 23 June in 1986; clutch size and RCM for 6 females was 12.7 eggs per clutch and 0.106 respectively (Rowe 1987). No egg laying was observed in Chelydra at Chain O'Lakes, however; Budhabhatti (1987) observed a nesting attempt on 28 May in 1986.

Diet: Stomach (19) and fecal (15) samples were obtained from Chrysemys, and the contents identified to the lowest possible taxa (Table 4). Most samples contained a mixture of plant animal material. Based on stomach samples, plants had a 94.7% frequency of occurrence and comprised almost 60 percent of the total volume consumed (Figure 7). The most frequent plants in the diet were Ceratophyllum demersum (57.8%), Spirogyra (36.8%) and Lemna minor (31.5%).

Table 3. Monthly capture rate for turtles of all species at the Fox River site in Chain O' Lakes State Park during the spring and summer 1987.

Month	# Turtles Captured	Total hrs. trapped	Turtles/ Trapping hr.
April	2	76.0	0.026
May	61	4431.5	0.015
June	28	1863.0	0.015
July	29	3336.0	0.009
August	5	2490.0	0.002
September	0	259.0	0.000

Table 4. Dietary analysis (stomach n=19, fecal n=15) of <u>Chrysemys picta</u> from the Fox River site in Chain O' Lakes State Park in 1987. S denotes stomach sample, and F denotes a fecal sample. Amounts are expressed in percent per milliliter to compensate for different sample sizes. A plus (+) denotes an unmeasureable trace.

Taxon	Frequency of Occurrence		Mean Individual Volume		Total Volume	
	S	F	S	F	S	F
Plant material	94.7	100.0	44.2	60.0	55.6	81.4
<u>Spirogyra</u>	36.8	70.6	19.3	42.8	46.2	71.1
<u>Ceratophyllum demersum</u>	57.8	64.0	6.8	3.5	6.7	6.2
<u>Lemna minor</u>	31.5	52.9	8.0	0.20	1.8	0.04
Grass sp. Gramineae	26.3	35.4	+	0.0	+	0.10
Roots	5.3	0.0	+	12.5	+	0.12
Seeds	0.0	6.7	0.0	+	0.0	+
Detritus	21.0	88.8	2.8	10.4	0.75	15.2
Unidentified Plants	26.3	13.3	1.1	+	0.75	0.73
Animal Material	100.0	94.0	70.3	28.1	38.7	12.0
<u>Insecta</u>	68.4	76.5	29.5	10.2	24.6	3.2
Tricoptera	42.1	35.3	6.2	4.8	3.1	2.5
Hemiptera Belostomatidae	10.5	41.2	5.8	+	11.5	+
Coleoptera Dytiscidae	5.3	6.7	+	+	+	+
Diptera Tipulidae	10.5	26.7	0.08	+	0.23	+

Table 4. cont.

Odonata						
Zygoptera	26.3	20.0	5.7	1.2	2.8	0.42
Anisoptera	5.3	6.7	3.1	+	1.1	+
Hymenoptera	0.0	13.3	0.0	+	0.0	+
Lepidoptera	5.3	6.7	1.6	+	4.5	+
Ephemeroptera	5.3	0.0	+	0.0	+	0.0
Unidentified Insect Material	26.3	66.7	4.7	1.8	1.1	0.10
Crustacea						
Amphipod	15.8	13.3	+	+	+	+
Mollusca						
Pelycypoda	5.3	6.7	4.8	+	0.38	+
Gastropoda	10.5	40.0	1.2	0.23	1.5	0.58
Annelida						
Hirundinea	15.8	6.7	+	+	+	+
Platyhelminthes						
Nematoda	15.8	13.3	+	+	+	+
Vertebrata						
Osteichthyes	21.0	26.7	6.4	2.1	1.9	0.30
Unidentified Animal Material	78.9	73.3	29.4	8.5	10.0	3.8
Silt	0.0	46.7	0.0	17.6	+	5.2

Spirogyra made up 46.2% of the total volume.

Animal matter occurred in all stomach samples analyzed. Insects were the most common animal food taken. The orders Tricoptera (68.4%), Odonata (Zygoptera) (26.3%), Hemiptera (10.5%) and Diptera (10.5%) were most frequently eaten. Amphipods, fish and snails were less commonly ingested.

Plant material occurred in much higher frequencies in fecal samples. *Spirogyra* was present in 71% of the samples. *Ceratophyllum* and *Lemna* were also more prevalent in fecal samples. Detritus and silt had high frequencies in fecal material; but they were lacking in stomach analyses.

Insect material in fecal samples was chiefly comprised of exoskelton and pupal cases. Unidentifiable insect material was present in 67% of the samples; this accounted for less than one percent of the total volume. Gastropod shell fragments were found in 40% of the fecal samples, but only occurred in 10.5% of all stomach samples examined.

Overlap Between Species: Morisita's index (Horn, 1966) was used to determine the degree of food overlap (calculated in percent) between the chelonian species at Chain O'Lakes. *Chrysemys* and *Emydoidea* showed the least amount of overlap (29.9%). *Chrysemys* was most similar to *Chelydra* with a 68.5% overlap in diets.

H'diversity index (Schoener, 1968) was utilized to indicate the degree of specialization in the diets of the three species. Chrysemys had the most generalized diet (2.3) followed by Chelydra (2.0) and Emydoidea (1.7).

Feeding Behavior : Chrysemys utilized the surface vegetation mats for the preponderence of their activity. Painted turtles were usually observed foraging on the surface of the vegetation mats throughout the habitat. A typical example was a small turtle observed on 16 June in pond D moving about the top of a Ceratophyllum mat in the south end of the pond. The turtle moved slowly over the surface periodically lunging at objects not evident to the observer. The direction of its movement was dictated by the shape of the vegetation mats. Upon reaching the edge of a mat, it swam underwater to the next mat. Throughout the foraging, the carapace was exposed and the head was held at the surface or slightly below.

Emydoidea usually forages in shallow water around the bases of cattails, sedges and grass clumps using their snout to probe the vegetation and substrate and the forelimbs to push away stems and other obstructions (Rowe, 1987).

Feeding habits of Chelydra are more varied (Budhabhatti, 1987). Snappers ambush prey from concealment in the muck, actively swim after fish and aquatic insects, or stealthfully approaching prey from beneath striking them at the surface. The most peculiar feeding behavior observed was a large male which regularly used a neustophagic technique to feed on *Lemna*.

DISCUSSION

In the northern portion of its range, *Chrysemys* tends to be the most common chelonian in aquatic ecosystems. At the Fox River site, it outnumbered *Emydoidea* and *Chelydra* 9.7: 1.4: 1. Congdon et. al. (1986) found *Chrysemys* to be three to seven times as dense as cohabiting species in a Michigan marsh. In Pennsylvania, Ernst (1971) found a 21:1 *Chrysemys* to *Chelydra* ratio.

Densities at the study site were only moderate compared to published reports (Table 5) which range from 11.1 to 590/ha. The estimated density for the study area was 114.1/ha with the intrasite densities varying from 21.4 to 139.5 /ha. *Emydoidea* (11.7) and *Chelydra* (8.6) densities are similar to the 8.8 and 13.3 turtles/ha determined by Congdon et al. (1986) in a marsh in Michigan.

Total biomass per hectare may be a better indicator of relative density. At the Fox River site, *Chrysemys*, the most populus species, was second in total biomass. Congdon et al. (1986) also found that small-bodied turtles, with the densest populations, did not always have the highest biomasses. At Chain O' Lakes, *Chelydra* with 24kg/ha in biomass exceeded *Chrysemys* with 15kg/ha and *Emydoidea* with 11 kg/ha.

Table 5. Published density accounts (# of turtles/ha) of *Chrysemys picta* listed in descending order of magnitude.

Locality	Density	Habitat	Source
Pennsylvania	590/ha	Pond and adjacent marsh	Ernst (1971)
Michigan	576/ha	Marsh with grass-sedge assn.	Gibbons (1968)
Nebraska	160-333/ha	Highly eutrophic oxbow	McAuliffe (1978)
Michigan	99-295/ha	Pond and associated marsh	Sexton (1959)
New York	27/ha	Pond with rock shores little veg.	Bayless (1975)
Saskatchewan	11/ha	Riverine ecosystem	MacCulloch and Secoy (1983)

The density and biomass of Chrysemys relative to the other chelonians at the Fox River site is possibly explained by two hypotheses: 1) they are directly correlated with the quality of available habitat. 2) they are a result of interspecific competition. In the first hypothesis, Chrysemys does appear to have larger populations and densities in areas of lush aquatic vegetation (see Table 5). At the study site, ponds D and E, which had the highest diversity of plants, also had the greatest densities of Chrysemys. The painted turtles reliance on vegetation is supported by Meseth and Sexton (1963) who noted that Chrysemys emmigrated from ponds in which the vegetation had been experimentally removed. They suggested that Chrysemys depends on the structure of the vegetation for physical support. In ponds A-C, the only vegetation is Chara that usually does not come to the surface except for the shallow margins. In this study, the lowest density of Chrysemys but the highest densities of Emydoidea and Chelydra occurred here.

Interestingly, ponds A, B and C support as high or higher biomasses of turtles overall than the more productive D and E. This is in contrast with Congdon et al. (1986) who found that pond habitats support lower biomasses of turtles than do marsh habitats, but agrees with the findings of Iverson (1982) that areas of high primary productivity (i.e. marshes, swamps and bogs) do not support the highest biomasses of turtles. Although the total biomass estimates of the ponds were similar, the species composition was different. Ponds D and E had the greatest overall density of turtles, but ponds A, B and C had greater biomasses per hectare due to the high densities of larger species (eg. Chelydra in ponds B and C, and Emydoidea in pond A).

Alternatively, the abundance of Chyrsemys may be controlled by interspecific competition. Relative densities of sympatric species of turtles may be a reflection of the degree of interspecific competition that exists. If competition for food or habitat is present, then the competing species will have lower densities where they occur together. For example, Berry (1975) found that when two sympatric species of Sternotherus occurred together in northern Florida, S. minor always had the smaller population. Density calculations for the Fox River site show, Chrysemys predominated in all habitats, but hadtheir lowest density where Chelydra were most dense (i.e. ponds B and C). Chyrsemys displayed the greatest degree of food overlap with Chelydra (Morisita's index .685). However, since ponds B and C lack surface mat vegetation, it is not clear whether competition, sub optimal habitat or the combination explains the low density of painted turtles in the area.

Relative density and biomass of these turtles may be influenced by factors other than productivity and competition. For example, Iverson (1982) has reported that herbivorous turtles tend to have higher biomasses than omnivorous or carnivorous ones. At the study site Chrysemys, the most omnivorous, had the greatest density and was second in biomass. Emydoidea, the most carnivorous, is second in density and lowest in biomass.

Whatever role food competition has played in determining relative densities, it has been insufficient to eliminate any of the three species. Differences in food types, feeding behavior, habitat useage, temporal and spatial activity likely allow for coexistence (Table 6).

The diets of the three sympatric species at the Fox River site overlapped considerably but with some differences. Chrysemys the most generalized had the greatest Morisita's index overlap with Chelydra (.685), while Chelydra and Emydoidea displayed the highest degree of overlap of the three (.804). Berry (1975) found that in areas of sympatry, where resources are limiting, character convergence was evident. He noted that where Sternotherus odoratus and Sternotherus minor occurred together, the latter became smaller and abandoned specialized feeding on mollusks. Such " character convergence" is predicted when resources are limited and generalized (Berry, 1975). Vogt (1981) observed two different effects of competition within three species of sympatric Graptemys. Where G. pseudogeographica and G.

Table 6. Comparisons and contrasts of the three species of turtles that inhabit the Fox River site at Chain O' Lakes State Park.

	C. picta	*E. blandingi*	*C. serpentina*
Density ha	114.1	11.7	8.6
Biomass kg/ha	15.0	11.0	23.7
Movement	most sedentary	most itinerant	majority are sedentary, some itinerant
Food	most omnivorous	most carnivorous	omnivorous
H'*	(2.3)	(1.7)	(2.0)
Sex ratios	1:1	1:1	4:1
Daily Activity	primarily diurnal with freq. noct. activity	diurnal occass. nocturnal activity	diurnal occass. nocturnal activity
Foraging sites	surface mats	shallows around plant clumps	ambush, active pursuit (all levels)
Feeding times	continuous	bimodal	bimodal
Home range/ha	(0.38)	(2.2)	(9.5)
Relative clutch mass (RCM)	0.103	0.106	0.085*

* H' index of specialization taken from Schoener (1968).

** Derived from Congdon et al. (1986).

geographica occur sympatrically *G. pseudogeographica* undergoes character displacement and developes a more generalized diet. In areas of allopatry, both tend to be molluscivorous. This reduced overlap with *G. geographica*, but increased overlap with *G. ouachitensis* the most generalized feeder of the three.

The situation at the Fox River site differs in that the three species are not congeneric. There is no apparent convergence in size among the three species. *Chrysemys* ate plant and animal material in nearly equal amounts. *Chelydra* varied in feeding habits with individuals ranging from total carnivory to total herbivory (Budhabhatti, 1987), and *Emydoidea* was mainly carnivorous utilizing clumped food sources, such as mollusks a resource little used by *Chrysemys* (Rowe, 1987). The differential degrees of specialization of diet in the three turtles help alleviate competition and allows cohabitation.

Temporal differences in periods of activity further reduce competition. *Chrysemys* were the most nocturnal of the three species. Previously, *Chrysemys* have been described as diurnal almost exclusively (Ernst, 1971; Sexton, 1959). *Chrysemys* were typically active well after dark at the study site, which may allow exploitation of resources not available to *Chelydra* and *Emydoidea*, which were found to be only occasionally active at night (Budhabhatti, 1987; Rowe, 1987).

Foraging sites and feeding behavior of Chrysemys also differed from the other two species. Vogt (1981) and Vogt and Guzman (1988) indicate that differential utilization of habitat may be important in alleviating competition in turtles. Chrysemys tends to be more of a surface feeder, concentrating their activity on top of the vegetation mats.

Emydoidea, as described by Rowe (1987), is more likely to forage in shallow water. Budhabhatti (1987) saw a variety of feeding behaviors in Chelydra, including pursuit and sit and wait ambush on the bottom. Such differentiation in habitat usage again reduces the potential for food competition. Chrysemys were least transitory of the three turtles at the site. Movements within a site may result from competitive pressures while long distance movements can be attributed to unfavorable habitat conditions (Gibbons, 1986). Emydoidea are the most nomadic turtles at the site, making exploratory sallies of varying distances and moving seasonally from the less productive ponds to the eutrophic pond E (Rowe, 1987). Habitat quality is the suggested reason. It seems as if the degree of carnivory is a determining factor for spatial movements. Chrysemys has the smallest home range and also the most generalized diet, while Emydoidea tends to be carnivorous and nomadic. Their requirements may be only met by moving as resources are depleted.

CONCLUSIONS

1. *Chrysemys*, the most generalized chelonian at the Fox River site in Chain O' Lakes State park, is the most dense species, but it is second to *Chelydra* in biomass.
2. Intrasite differences in density and biomass can be attributed to quality of habitat and/or competition, but the importance of these factors needs more study.
3. Interspecific competition between the sympatric species may be alleviated through differences in diet, foraging behaviors, temporal differences and spatial activities.

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Figure 1. Maps of pond A, B and C (top to bottom) at the Fox River site in Chain O' Lakes State Park and its associated vegetation.

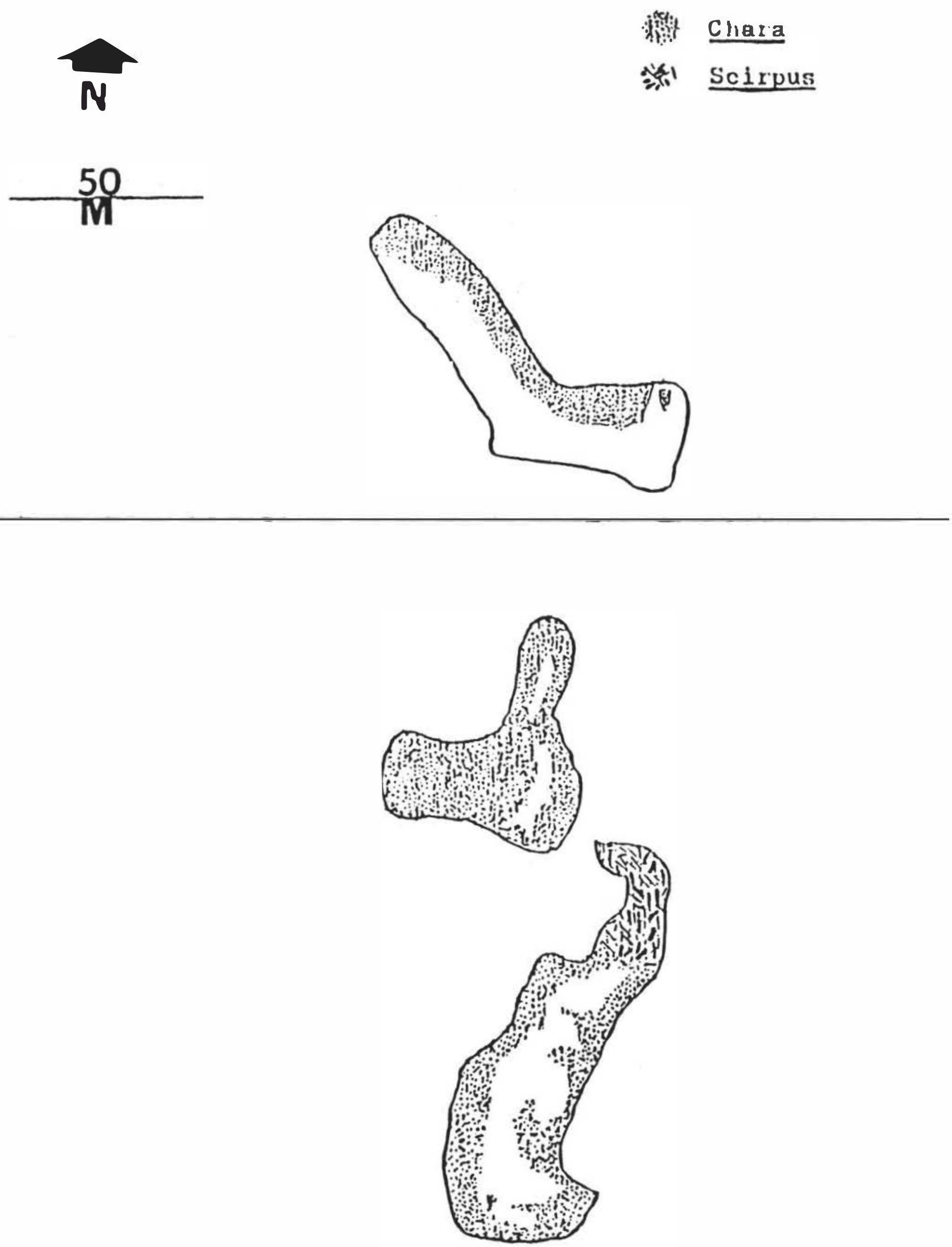

Chara
Scirpus
N
50
M

Figure 2. Map of pond D at the Fox River site in Chain O' Lakes State Park and its associated vegetation.

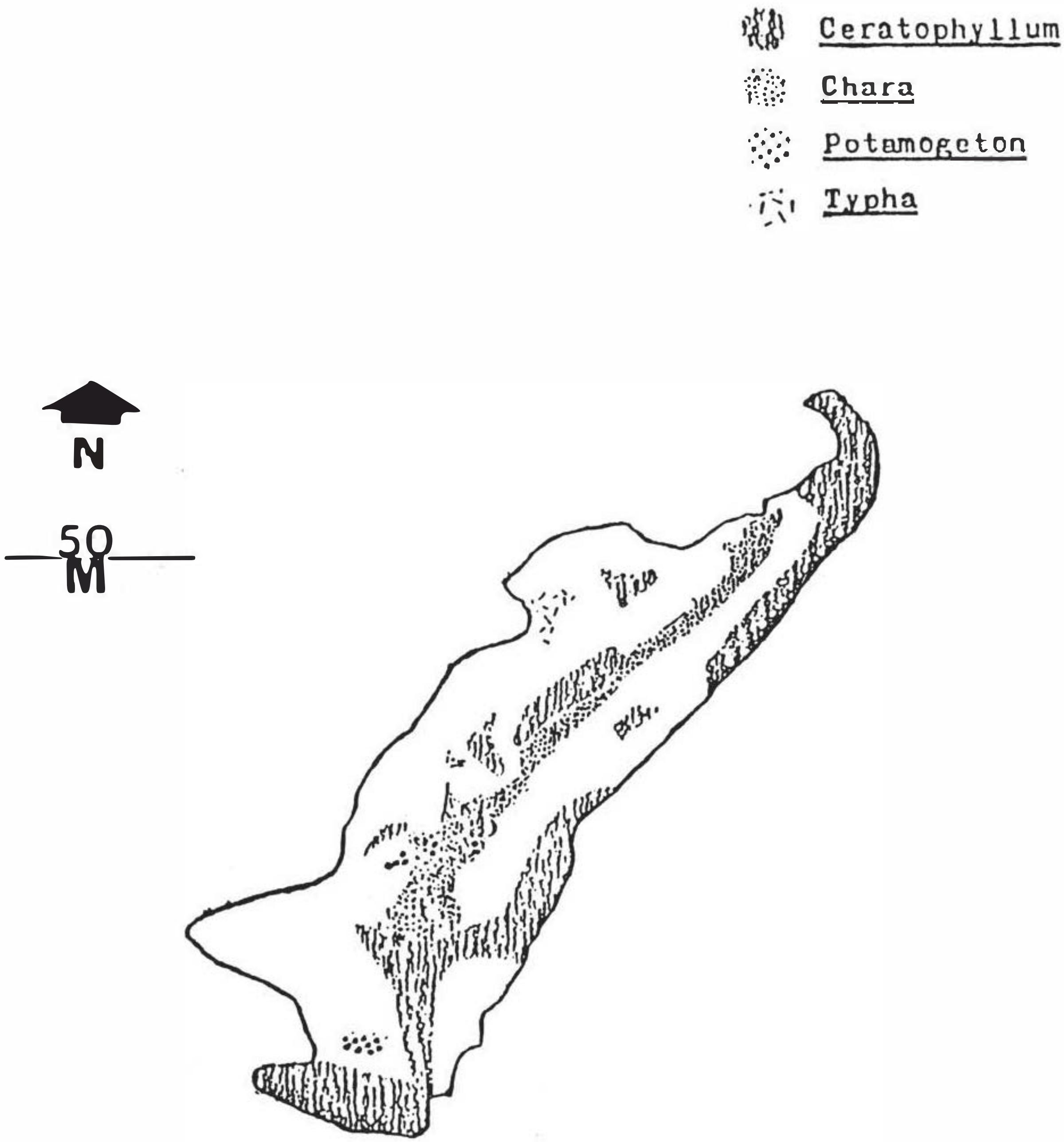

Ceratophyllum
Chara
Potamogeton
Typha
N
50
M

Figure 3. Map of pond E at the Fox River site in Chain O' Lakes State Park and its associated vegetation.

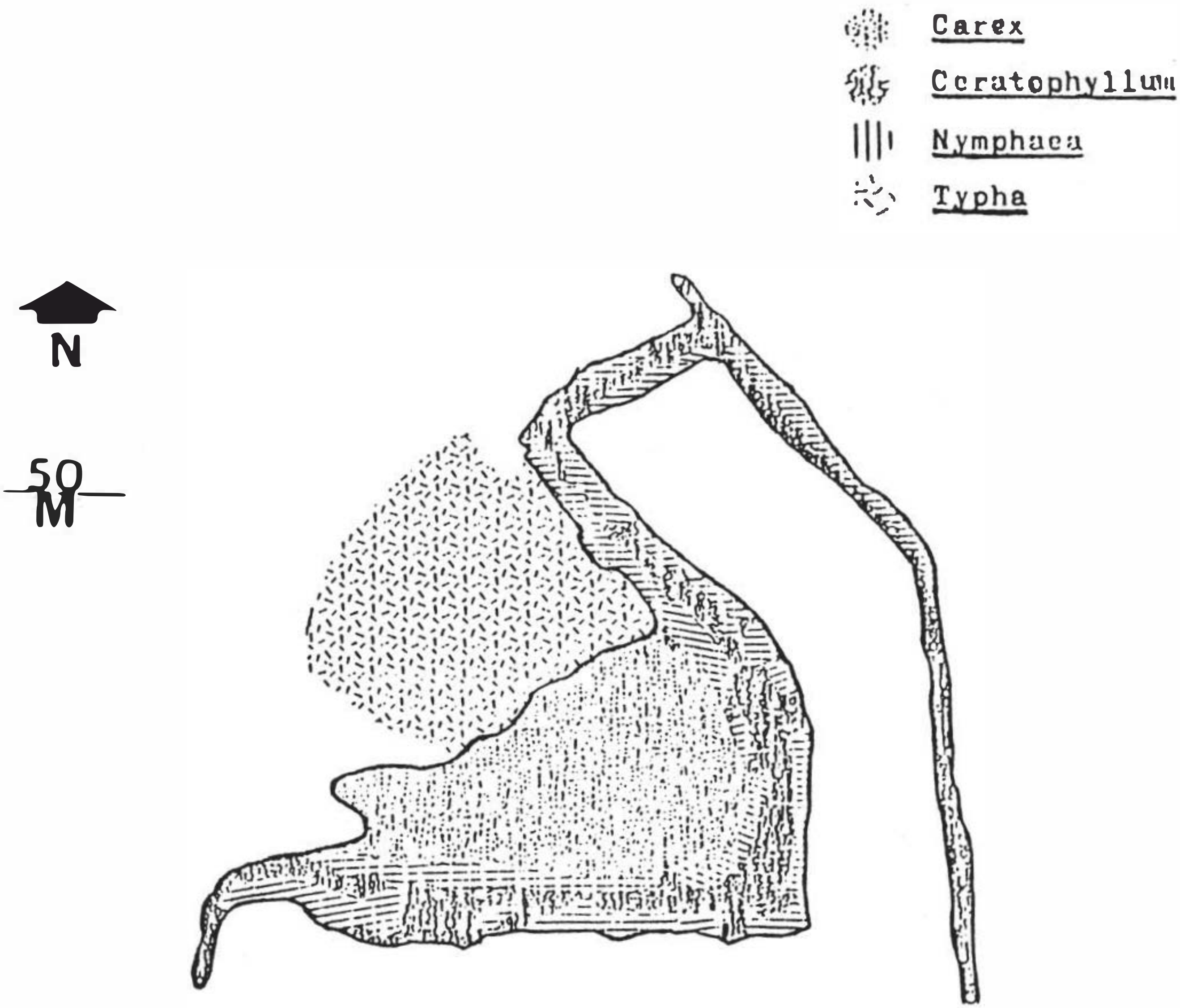
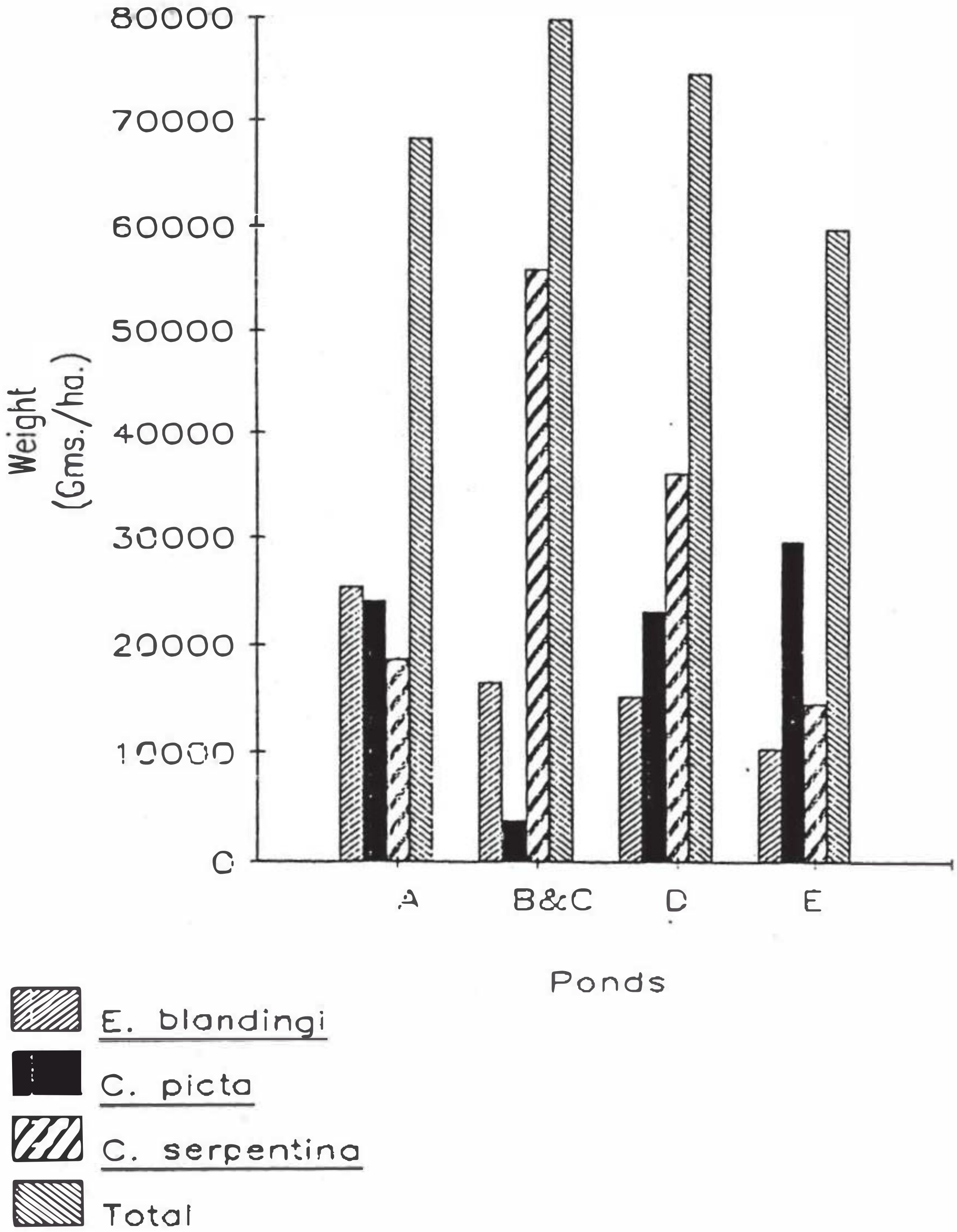

Carex
Ceratophyllum
Nymphaea
Typha
N
50
M

Figure 4. Estimates biomass of three species of turtles in ponds A-E at the Fox River site in Chain O' Lakes State Park.



80000
70000
60000
50000
40000
30000
20000
10000
0
Weight (Gms./ha.)
A
B&C
D
E
Ponds
E. blandingi
C. picta
C. serpentina
Total

Figure 5. Home range of 1,2,11L 9R (male) during the summer of 1987 in pond D.

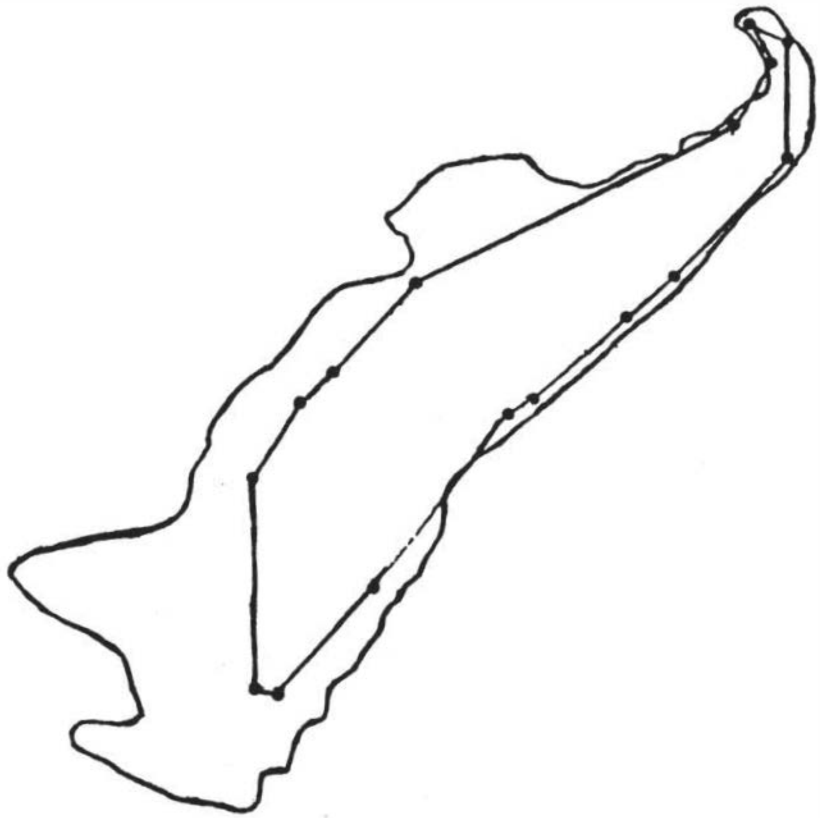


Figure 6. Home range of 3L 3R (female) during the summer of 1987 in pond D.

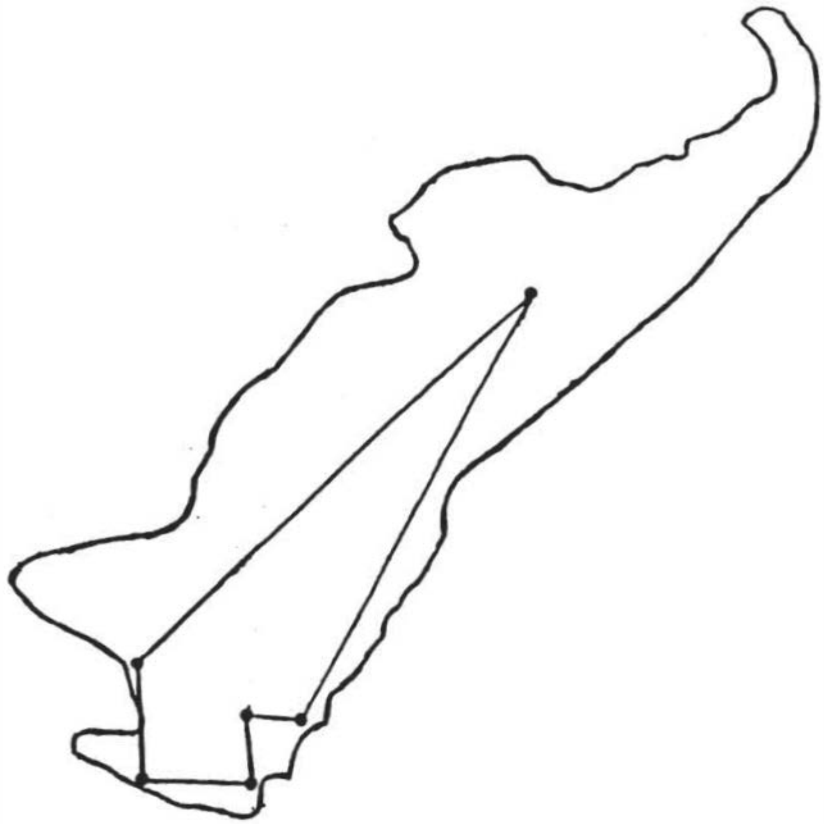
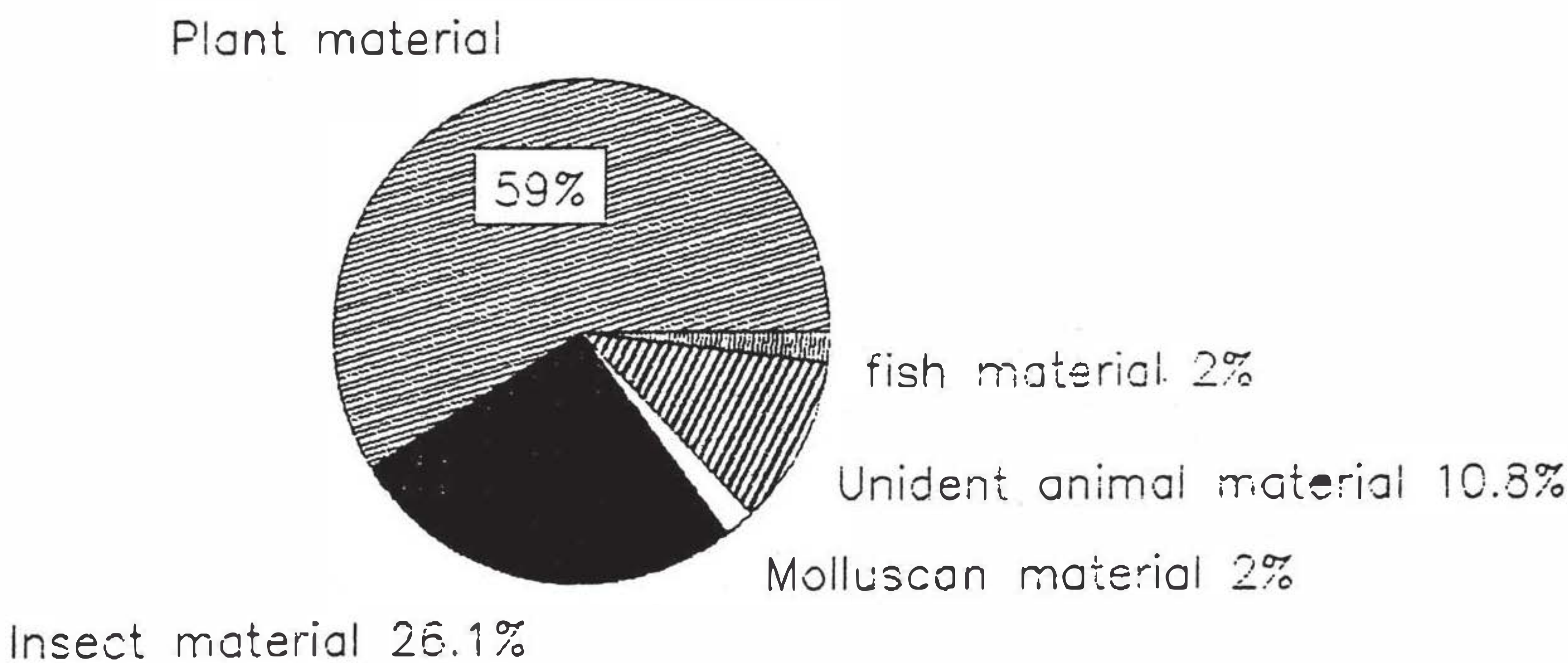


Figure 7. Diet in percentages of the most common food types of *Chrysemys picta* at the Fox River site in Chain O' Lakes State Park.


Plant material
59%
fish material 2%
Unident animal material 10.8%
Molluscan material 2%
Insect material 26.1%